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COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS

UPPER CAMBRIAN FOSSILS

From

BUCKS COUNTY, PENNSYLVANIA

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B. F. Howell

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TOPOGRAPHIC AND GEOLOGIC SURVEY
BULLETIN G28
1957

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UPPER CAMBRIAN FOSSILS
From
BUCKS COUNTY, PENNSYLVANIA

By

B. F. HOWELL

DEPARTMENT OF INTERNAL AFFAIRS
GENEVIEVE BLATT, *Secretary*
TOPOGRAPHIC AND GEOLOGIC SURVEY
CARLYLE GRAY, *State Geologist*

1957

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PREFACE

This paper was originally submitted as a chapter in "Geology of Bucks County," Bulletin C9, Pennsylvania Geological Survey 4th Series. Because of the importance of this paper, and because of the highly specialized subject, it is felt that in issuing it as a separate publication it will be more readily available to those interested in the subject. Some of the procedures in naming of new species in this paper are not strictly in accord with current standards. While the Pennsylvania Geological Survey would not ordinarily accede to the naming of some of the new species which are based on a small number of specimens, some of which are poorly preserved or weathered, we have in this case bowed to the judgment of the author who has had wide experience with Cambrian faunas.

Since the "Limeport" formation has not been mapped separately in the area, the Pennsylvania Geological Survey does not, as of yet, regard this as a valid formation. On the geologic map of Bucks County these beds are included in the Conococheague formation. Because of the doubt and differences of opinions that exist in regard to the "Limeport" formation, we believe this paper merits special attention. Perhaps through detailed studies of this kind, the difficult problems of stratigraphy and structure in areas of limited exposure such as this will be solved eventually.

The Editors.

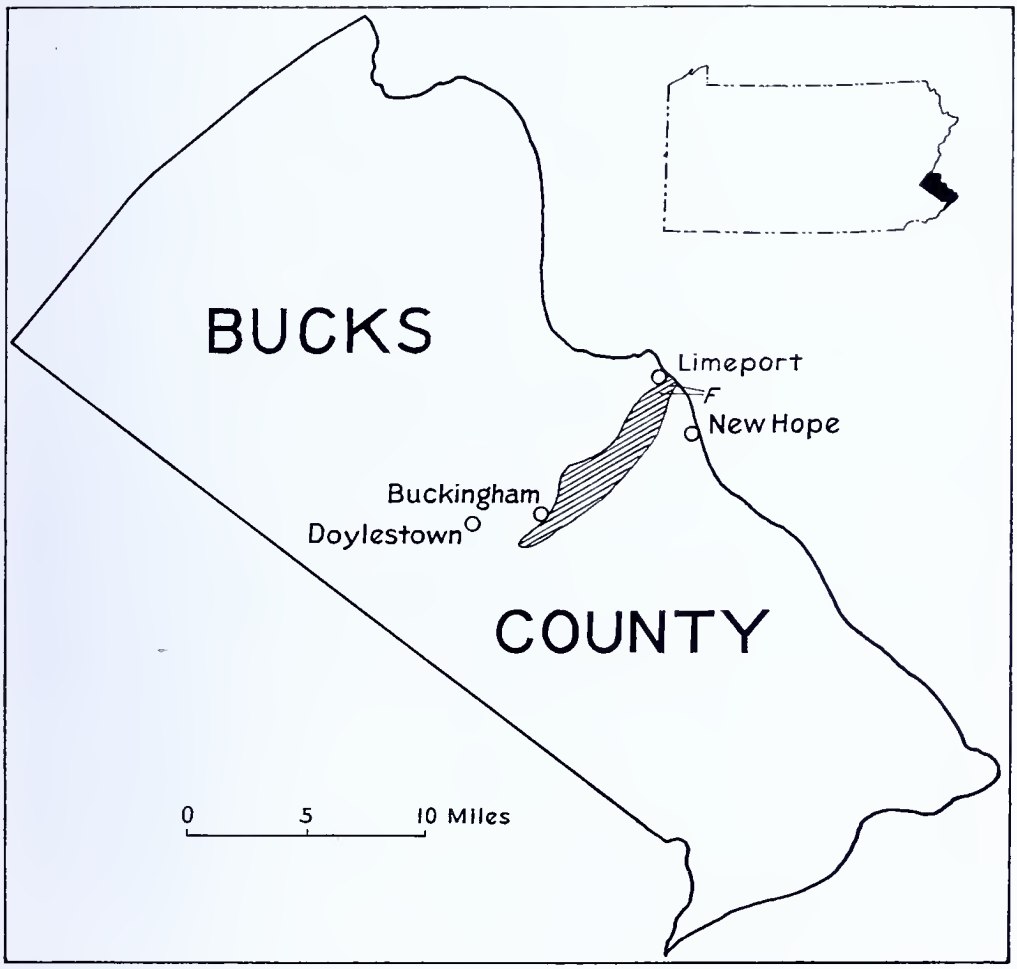

FIGURE 1. Sketch map of Bucks County showing location from which the fossils were collected.

UPPER CAMBRIAN FOSSILS
FROM
BUCKS COUNTY, PENNSYLVANIA

BY
B. F. Howell[1]

ABSTRACT

Fossils of four closely related faunas of Dresbachian, early Late Cambrian, age from the vicinity of Limeport, Bucks County, Pennsylvania, are described: 3 species of *Lingulella* (1 new), 2 species of *Lingulepis* (1 new), 1 new species of *Pemphigaspis,* 2 new species of *Welleraspis,* 3 species of *Talbotina* (2 new), 4 new species of a new genus of trilobites, *Bucksella,* 3 new species of *Lonchocephalus,* 1 new species of *Coosia,* 1 new species of *Coosella,* 1 new species of *Genevievella,* and 3 new species of *Indianites* are described.

INTRODUCTION

Although the Upper Cambrian rocks of Bucks County have been mapped and discussed by a number of authors in the past and identifications of two of the species of fossil animals found in them have been made by E. O. Ulrich (in Bascom et al, p. 5, 1909), the only publication in which Cambrian fossils from them have been figured and described is one by Fenton and Fenton (1937) which dealt with calcareous algae. As a number of other kinds of fossils than algae have been found in these rocks, and as our present knowledge of the time ranges of Upper Cambrian genera of trilobites now permits us to use some of these fossils to determine the age of some of the Upper Cambrian strata in Bucks County, the faunas of these rocks are described here and their age is discussed.

Four closely related, but somewhat different, faunas have been found in the Upper Cambrian strata of Bucks County. The species of each of these four faunas are listed below. All of the faunas are of early late Cambrian, Dresbachian, age. Two of the faunas are present in a single stratigraphic section in the southern of two limestone quarries at Limeport, two miles northwest of New Hope.* In this quarry there is a disconformity between the beds holding the older of these two faunas and those containing the younger fauna. The fossils of the other two faunas are found in scattered outcrops of limestone within a radius of a few miles of this quarry; but the stratigraphic horizons of these other two faunas relative to those of the two faunas in the Limeport quarry is not known.

The relative ages and relationships of the four faunas are discussed on the pages following on which the various species of the faunas are described. All of the beds in which the four faunas are preserved are believed to be in the Limeport formation.

---

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* Not to be confused with Limeport in Lehigh County, Pennsylvania. The Bucks County localities are marked by F on the County geologic map-Pl. 2, Bulletin C9, Geology of Bucks County, Pennsylvania, Geological Survey 4th Sers. and on the sketch map, Figure 1.

DESCRIPTION OF THE FOSSILS

Phylum BRACHIOPODA
Class INARTICULATA
Order ATREMATA
Family OBOLIDAE
Subfamily LINGULELLINAE
Genus **Lingulella** Salter (1886)

Lingulella modesta Lochman
(Pl. 1, fig. 1)

Lingulella modesta LOCHMAN, Journal of Paleontology, vol. 14, 1940, pp. 16-17, pl. 1, fig. 22.

A single imperfect valve of a small species of *Lingulella* was found in the lower beds exposed in the north wall of the southern quarry at Limeport, below the disconformity referred to above. It is probably a dorsal valve of *Lingulella modesta*, a species originally described by Lochman from the early Dresbachian *Cedaria* zone of Missouri. It is 4 mm. long and 3 mm. wide. The shell is flattened; its inner layer is not preserved, and the small portion of the outer layer that remains is so poorly preserved that it does not show any of the radiating costellae which Lochman says are characteristic of the species; but the dimensions are correct for a dorsal valve of *L. modesta* and the age is correct for that species; so it can be reasonably identified as such.

The specimen is No. 56933a in the paleontological collection of Princeton University.

Occurence. In the beds of the Limeport formation in the lower part of the section exposed in the southern quarry at Limeport, below the disconformity.

Discussion. Although thousands of specimens of trilobites have been found in these beds, the only example of a brachiopod found is the dorsal valve of this species.

Lingulella rugosa Howell, n. sp.
(Pl. 1, figs. 2-5)

Ventral valve rather convex for a *Lingulella*, tapering evenly backward to a bluntly pointed beak. Shell thick, the surface marked by well-developed concentric lines of growth and by fine longitudinal ridges and striae which radiate forward from the beak to the anterior edge of the valve. These ridges and striae are not as straight and continuous as is usually the case in other species of *Lingulella* whose shells bear such markings, and they are distributed over the entire outer surface of the shell.

Dorsal valve almost circular in outline and more convex than is usual in the genus. The shell is thick and has the same markings on its surface as does the ventral valve. In the few examples of the species that have been found the surface ornamentation of the dorsal valve is a little better de-

veloped than is that of the ventral valve; and the dorsal valve has almost a wrinkled appearance.

Ventral valves are 5 mm. long and 4 mm. wide; dorsal valves are 4 mm. long and 4 mm. wide. The internal characters cannot be seen on our specimens.

The holotype is a dorsal valve, No. 56465 in the Princeton University collection. Paratypes are dorsal and ventral valves, Nos. 56466-56474.

Occurrence. The holotype and all but two of the paratypes are from a thin-bedded dark-gray, almost black, very fine-grained limestone of the Limeport formation in a quarry northwest of New Hope. The two other paratypes are from a fine-grained dark-gray limestone of the Limeport formation west of New Hope.

Discussion. The valves of this species are so short and convex that the species may not be properly referable to *Lingulella.* However, the dorsal valves do resemble in form and external features those of *Lingulella texana* Walcott, the internal features of which are known, so that its reference to *Lingulella* is based on satisfactory evidence. Unfortunately, the ventral valve of *L. texana* is not known. That species has been reported only from the "sandstones at the base of the Elvins formation" (Walcott, 1912) in Missouri and is therefore of earliest Franconian (medial late Cambrian) age and is consequently a little younger than *L. rugosa;* but the two species may belong to the same evolutionary line within the genus *Lingulella.* The dorsal valve of *L. rugosa* differs from that of *L. texana* in being a little smaller and more nearly circular in outline and in having the external markings less strongly developed.

Lingulella aff. prima (Hall)

(Pl. 1, figs. 6-8)

Ventral valve subcircular in outline except that the beak, which is obtusely pointed, extends a short distance to the rear. Convexity moderate. Shell thick, with the growth lines clearly, but not very strongly, developed, and with well-developed, fine, radiating, ridges on the inner layer.

Dorsal valve similar to ventral valve except that the beak is small and blunt.

No internal characters can be distinctly seen on any of our specimens.

The specimens of this brachiopod are Nos. 56847a, 56845, 56846, 56847b, 56848-56850, and 56857 in the Princeton University collection.

Occurrence. In fine-grained, thin-bedded, gray limestone of the Limeport formation 2 miles northwest of New Hope in association with *Lingulepis pinnaformis* (Owen)

Discussion. Our specimens of this brachiopod are poorly preserved; but they appear not to be certainly referable to any previously described species. They belong to the group of species of *Lingulella* that are broad in relation to their length. The finding of better preserved specimens may prove that they belong in one of the already described Dresbachian forms of the genus; but this does not seem probable in the light of our present

knowledge of the faunas of the Limeport formation. The author is indebted to Professor W. C. Bell for assistance in determining the generic affinities of this species. Professor Bell thinks that the species may belong in the genus *Lingulepis;* but until better specimens are discovered it is perhaps best to assign them to *Lingulella.* This *Lingulella* is probably closely related to *L. prima* (Hall), of the Potsdam formation of New York. It has the general form of that species, but its shells on the average are somewhat smaller in size. *L. prima* is probably a species of the *Crepicephalus* zone, which overlies the *Cedaria* zone, in which our brachiopod probably lies; and *L. prima* may have evolved from our form. The two species may even be identical; but this cannot be proved with the specimens of our form now available; and, because the species appear to belong in two different faunal zones, it seems best to call the Bucks County form *Lingulella* aff. *prima* (Hall) for the present.

Genus **Lingulepis** Hall (1863)

Lingulepis pinnaformis (Owen)

(Pl. 1, figs. 9-11)

*Lingula pinnaformis** Owen, Rept. Geological Survey Wisconsin, Iowa, and Minnesota, 1852, p. 583, pl. 1B, figs. 4, 6, and 8.

Lingula Prima Owen, **Hall,** Report of the Geology of the Lake Superior Land District, by Foster and Whitney, pt. 2, 1851, p. 204, pl. 23, figs. 1a-g.

Lingula antiqua Emmons, **Hall,** Report of the Geology of the Lake Superior Land District, by Foster and Whitney, pt. 2, 1851, pp. 204-205, pl. 23, figs. 2a-c.

Lingula antiqua Emmons, **Hall,** Rept. Geology of Wisconsin, vol. 1, 1862, p. 21, fig. 2.

Lingula pinnaeformis Owen, **Hall,** Rept. Geological Survey Wisconsin, vol. 1, 1862, p. 435, fig. 3.

Lingula antiqua Emmons, **Hayden,** American Journal of Science, 2nd ser., vol. 33, 1862, p. 73, text-figs. 1a-b.

Lingulepis pinnaformis (Owen), **Hall** (in part), 16th Rept. New York State Cabinet of Natural History, 1863, pp. 129-130, pl. 6, figs. 14-16 (not figs. 12 and 13).

Lingulepis pinnaformis (Owen), **Meek and Hayden,** Smithsonian Contributions to Knowledge, No. 172, Paleontology of the Upper Missouri, 1865, pp. 2-3, pl. 1, figs. 1a-b.

Lingulepis dakotensis **Meek and Hayden,** Smithsonian Contributions to Knowledge, No. 172, Paleontology of the Upper Missouri, 1865, p. 3.

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* A full bibliography of this widely distributed species is presented here because *L. pinnaformis* has been considered by some authors to be identical with *L. acuminata* (Conrad). The two species are distinct and are of different ages, *L. pinnaformis* being found in Dresbachian (lower Upper Cambrian) rocks and *L. acuminata* having lived in Trempealeauian (late late Cambrian) times.

Lingulepis pinnaformis (Owen), **Hall,** (in part), Transactions Albany Institute, vol. 5, 1867, p. 107, pl. 1, figs. 14-16 (not figs. 12 and 13).

Lingulepis pinnaformis (Owen), **Whitfield,** U. S. Geographical and Geological Survey of the Rocky Mountain Region, Report Geology and Resources Black Hills of Dakota, 1880, p. 335, pl. 2, figs. 1-4.

Lingulepis dakotensis Meek and Hayden. **Whitfield,** U. S. Geographical and Geological Survey of the Rocky Mountain Region, Report Geology and Resources Black Hills of Dakota, 1880, pp. 337-338, pl. 2, figs. 10 and 11.

Lingulepis pinnaformis (Owen), **Whitfield,** Geology of Wisconsin, vol. 4, 1882, pp. 169-170, pl. 1, figs. 2 and 3.

Not Lingulepis pinnaformis (Owen), **Dwight,** Proceedings American Association for the Advancement of Science for 1885, 1886, p. 208 (refers to *Lingulepis acuminata* Conrad).

Not Lingulepis pinnaformis (Owen), **Dwight,** American Journal of Science, vol. 31, 1886, p. 135 (refers to *Lingulepis acuminata* Conrad).

Lingulepis pinnaformis (Owen), **Hall and Clarke,** 11th Annual Rept. State Geologist of New York for 1891, 1892, p. 232, text-figs. 337 and 338, pl. 1, figs. 16 and 17.

Lingulepis pinnaformis (Owen), **Hall and Clarke,** 45th Annual Rept. New York State Museum for 1891, 1892, p. 548, text-figs. 237 and 238.

Lingulepis pinnaformis (Owen), **Hall and Clarke,** Natural History of New York, Paleontology, vol. 8, pt. 1, 1892, p. 60, text-figs. 22 and 23, pl. 1, figs. 35 and 36.

Lingulepis pinnaformis (Owen) **Schuchert,** Bulletin U. S. Geological Survey, No. 87, 1897, p. 260.

Lingulepis pinnaformis (Owen), **Grabau and Shimer,** North American Index Fossils, vol. 1, 1907, p. 193, text fig. 227.

Lingulepis acuminata (Conrad), **Walcott** (in part), U. S. Geological Survey Monograph 51, 1912, pp. 545-550 pls. 41, figs. 1, 1a-n, 42, figs. 1, 1a-j (not pl. 34, figs. 3, 3a-c, pl. 40, figs. 1, 1a-s, pl. 42, figs. 1k-o).

Lingulepis pinnaformis (Owen), **Shimer and Shrock,** Index Fossils of North America 1944, p. 285, pl. 107, figs. 1 and 2.

Ventral valve rather convex, especially toward the beak, which is long and attenuate. The front of the valve is evenly-rounded, but is not very greatly expanded. The length of a large valve is 15 mm. and the greatest breadth is 10 mm. The shell is thick and marked by concentric lines of growth and low, indistinct, radiating ridges, which can usually be seen clearly on only the anterior half of the shell.

Dorsal valve of same convexity as the ventral valve and with an equally thick shell, but relatively much shorter than the ventral valve (a large example is 14 mm. long and 13 mm. wide at its greatest width), with a bluntly rounded beak. The shell shows well-developed lines of growth

and faint radiating ridges, which in most specimens can be seen only on the anterior half of the valve.

The radiating ridges are more distinctly visible in exfoliated specimens of both valves. No internal characters are visible on any of our specimens from Bucks County.

The cotypes of *Lingulepis pinnaformis* are in the U. S. National Museum (No. 17860a). They are from the falls of the St. Croix River, in Polk County, Wisconsin. The late Dr. Ira Edwards informed the writer that the beds from which these specimens came are in the Eau Claire formation and may be in the *Cedaria* zone of the Dresbachian. Tophomeotypes of the species from this locality, identified and labeled by Dr. G. O. Raasch and now in the Princeton University collection (Nos. A987a and A987b) are marked as having come from beds in the Eau Claire formation which lie in the *Crepicephalus* zone of the Dresbachian; but, as noted above, Dr. Edwards thought that these beds might be in the *Cedaria* zone, which underlies the *Crepicephalus* zone. Our Bucks County plesiotypes, which appear to be identical with the tophomeotypes from Wisconsin in the Princeton collection, are Princeton Nos. 56835, 56837, 56840, 56842, and 56843.

Occurrence. Our Bucks County specimens are in a fine-grained, thin-bedded, gray limestone of the Limeport formation from 2 miles northwest of New Hope, in association with *Lingulella* aff. *prima*.

Discussion. This species differs from *Lingulepis acuminata* (Conrad) in being larger and in having the anterior portion of the valves wider and the beak of the ventral valve more extended, so that it is shaped like a long, narrow, spike. In these respects the Bucks County shells, all of which are ventral valves, resemble those of *Lingulepis walcotti* Resser, from the Dresbachian Nolichucky formation of Tennessee. *L. walcotti*, which is of about the same age as our species, or perhaps a little younger, may be identical with it or may be a somewhat younger descendant. Our shells are, on the average, somewhat smaller than the shells of *L. pinnaformis* found at the falls of the St. Croix River, in Wisconsin, and larger than those of *L. walcotti*. The Bucks County form, however, does not appear to differ enough from the Wisconsin one to require even a subspecific name. As no other species except *Lingulepis limeportensis* (described below) and *Lingulella* aff. *prima* occur in association with these brachiopods at the single locality where they have been found (2 miles northwest of New Hope), we have no evidence except that afforded by the brachiopods, themselves, as to the exact age of the beds in which they occur. If the beds holding *L. pinnaformis* at the falls of the St. Croix River are in the *Crepicephalus* zone, the beds containing that species in Bucks County may be in that zone also. If they are, they may be the highest beds bearing brachiopods yet discovered in the Limeport formation of Bucks County, for the other Limeport beds there that have yielded such fossils are probably in the *Cedaria* zone. It seems more probable, however, that the beds 2 miles northwest of New Hope that contain *L. pinnaformis* are in the *Cedaria* zone, for *Lingulepis limeportensis*, which occurs with *L. pinnaformis* at this locality, is found in association with typical *Cedaria* zone trilobites at Limeport. The *Cedaria* zone is early Dresbachian in age; the *Crepicephalus* zone is medial Dresbachian.

Lingulepis limeportensis Howell, n. sp.

(Pl. 1, figs. 12, 13)

Ventral valve 10 mm. long and 7 mm. wide, moderately convex, the convexity less near the front of the shell and greater near the beak. Front of valve evenly-rounded; beak extended, tapering evenly, or with only a little attenuation, to a sharp point. Growth rings well-developed on outer layer of shell; fine, radiating, ridges present on inner layer.

Dorsal valve similar to ventral valve in form except that the beak is not extended, the valve being only three-fourths as long as the ventral valve.

No internal characters can be seen on any of our specimens.

The holotype, a ventral valve, is No. 56416 in the Princeton collection. Paratypes are Nos. 56832 and 56836 in the same collection. The paratypes numbered 56836 are young dorsal and ventral valves. Four other specimens assigned to this species are Nos. 56838, 56839, 56841, and 56844.

Occurrence. In a fine-grained, thin-bedded gray limestone of the Dresbachian Limeport formation, in the upper beds of the southern quarry at Limeport, above the disconformity. Two dorsal valves (Nos. 56838 and 56839) and a ventral valve (No. 56841) from the similar limestone 2 miles northwest of New Hope are also believed to be referable to this species. They occur there with *Lingulepis pinnaformis* (Owen) and *Lingulella* aff. *prima* (described above).

Discussion. The writer knows of no other species that closely resembles this one. *L. acuminata* (Conrad) and *L. pinnaformis* (Owen) are somewhat larger species, with thicker shells, and have the front of the ventral valve more expanded and the beak more extended. *L. walcotti* Resser is nearer our species in size, but the front halves of both of its valves are relatively wider than they are in *L. limeportensis.* Furthermore, both *L. acuminata* and *L. walcotti* are younger than our Bucks County form. *Lingulella perattenuata* (Whitfield), which has been reported by Lochman (1940) from the *Cedaria* zone of Missouri, resembles our species in size and in its long and narrow form; but its ventral valve is not so narrow and acutely pointed toward the beak as it is in our species, and *perattenuata* is therefore a *Lingulella,* while *limeportensis* is believed to belong in the genus *Lingulepis.*

Phylum ARTHROPODA

Class TRILOBITA

Order OPISTHOPARIA

Family CATILLOCEPHALIDAE

Genus **Pemphigaspis** Hall (1863)

Pemphigaspis franklini Howell, n. sp.

(Pl. 2, fig. 1)

Known only from the holotype pygidium, which is incomplete, and one additional fragment.

Pygidium similar in form to that of *Pemphigaspis bullata* Hall, of the Upper Cambrian of the Upper Mississippi Valley, but somewhat smaller (the pygidium of our specimen is 3 mm. wide, while that of *P. bullata* is 4 mm. in breadth) and with a short and narrow, but distinct, border, which *P. bullata* apparently lacks.

The pleural lobes taper backward and are very bulbous, and the axis is reduced to a low and narrow ridge, which has 5 segments exposed in our specimen (the anterior part of the axis of which is not visible), and probably has 8, as does *P. bullata.* A fragment that is believed to be a pleural lobe of this species shows what appears to be a short marginal furrow at the front angle of the shield, but the specimen is too fragmentary for certain identification or determination of details.

The exoskeleton is smooth.

The holotype pygidium is No. 57010a in the Princeton collection. The paratype fragment, probably a pleural lobe of this species, is No. 57055.

Occurrence. In fine-grained, black limestone of the Limeport formation in the lower beds of the southern quarry at Limeport beneath the disconformity that is present there.

Discussion. The pygidium of this species is so similar to that of *P. bullata* Hall, that, except for the presence of the narrow border, it would have been assigned to that species. The lateral lobes are more globose than those of *P. bullata waddlensis* Tasch and *P. intermedia* Tasch (1951, p. 302) of the Warrior limestone of central Pennsylvania. It is intermediate in size between the pygidium of *P. bullata* and the smaller pygidium of *P. appalachia* Resser, of the Upper Cambrian Nolichucky formation of Tennessee. It differs from *P. appalachia,* however, not only in being larger, but in having tapering, not parallel-sided, pleural lobes and in possessing a border, which *P. appalachia* lacks. It is much smaller than the unnamed species of *Pemphigaspis* described by Lochman and Duncan (1944) from the Dresbachian *Crepicephalus* zone of the Pilgrim formation of Montana. It is wider than the pygidium of *P. inexpectans* Lochman, of the *Crepicephalus* zone of the Cap Mountain formation of Texas, and has a longer axis. Lochman and Duncan state that the species of *Pemphigaspis* known at the time of the publication of their memoir were "always associated with the *Crepicephalus* fauna," so our species, which appears to be in the *Cedaria* zone, would appear to be one of the oldest known representatives of the genus. Butts has recorded "*Pemphigaspis* cf. *bullata* Hall" from the Warrior formation of central Pennsylvania (Butts, 1936) but the writer has not seen the specimen, or specimens, on which this record was based and does not know how his species compares with them. The Warrior formation contains a *Cedaria* fauna and a *Crepicephalus* fauna, and the writer does not know in which of these faunas Doctor Butts found his *Pemphigaspis.*

P. franklini is named in honor of the author's son, who collected the holotype.

When Hall (1863) erected the genus *Pemphigaspis* he assumed that the shield on which the genus was based was the cephalon. Professor Franco Rasetti informed the writer that Professor C. H. Kindle had found a specimen of *Pemphigaspis* in Upper Cambrian beds on Murphy's Creek,

Quebec, that indicated that this kind of shield was the pygidium—perhaps the pygidium of the genus that had been named *Hallaspis* by Lochman and Raasch (1943). Professor Kindle has confirmed this report of the discovery of such a fossil in the beds of Murphy's Creek. *Hallaspis* was based on cranidia from the *Dresbachian Cedaria* zone and *Crepicephalus* zone of Wisconsin and Minnesota (*Amphion? matutina* Hall, 1863, was chosen as the genotype): Professor Kindle's specimen came from the Murphy's Creek formation of Quebec, which holds a *Crepicephalus* zone fauna. As Professor Kindle's discovery indicates that the genus *Pemphigaspis* includes *Hallaspis*, and, as "*Hallaspis*" occurs in the *Cedaria* zone of Wisconsin, it is not surprising to find *Pemphigaspis* in beds of the Limeport formation that appear to lie in the *Cedaria* zone. (See also Palmer, 1951, and Tasch, 1952).

Until recently, the family relationships of *Pemphigaspis* were uncertain. However, Professor Franco Rasetti informs the writer (personal communication) that it should be assigned to the Catillocephalidae.

Family SOLENOPLEURIDAE

Genus **Welleraspis** Kobayashi (1935)

Welleraspis lata, n. sp

(Pl. 2, figs. 2-9; Pl. 3, fig. 1, Pl. 4, fig. 2 part, Pl. 5, fig. 2 part)

Cranidium rather highly convex, especially the glabella, which is more convex than the fixed cheeks. Glabella three-quarters as wide as long, with parallel sides and front so bluntly rounded that it is square across the middle part of the front. Two pairs of well-impressed glabellar furrows, the anterior ones extending straight inward for about a quarter of the way across the glabella from each side, the posterior ones, which are more deeply impressed, extending straight inward as far as the anterior ones do and then turning back at an angle of 45° and continuing back almost to the occipital furrow. Faint pits, which may be traces of a still more anterior pair of furrows are present near the front corners of the glabella, are easily visible on some tests and seen only with difficulty on others. Dorsal furrow well developed all around. Occipital furrow well developed; occipital ring bearing a spine which is thick at its base, but tapers rapidly backward to a sharp point. Each fixed cheek about half as wide as the glabella in front of the palpebral lobe, but twice as wide behind that lobe. The palpebral lobes are of medium length and width, and there is a raised ocular ridge running from the front of it in a curved, diagonal line to the dorsal furrow, which it meets about opposite the faint pit on the anterior corner of the glabella. The fixed cheeks are very narrowly confluent in front of the glabella. The marginal furrow is well-impressed. The border is somewhat thickened and convex, but is not wide. It is not upturned; but, because of its thickness and high convexity, it rises well above the preglabellar area where the fixed cheeks meet. The border is marked by raised, anastomosing lines, and the rest of the outer surface of the cranidium is covered with fine tubercles. The inner surface of the test of the cranidium is punctate.

Free cheek rather narrow, with the part adjacent to the palpebral lobe much elevated above the general level of the cheek and with a somewhat convex border of medium width which is prolonged at the genal angle into a short, but acute, spine. The border is marked by raised anastomosing lines, but the surface of the rest of the cheek is smooth except for a faint pitting. The eye contains many very small lenses.

Hypostome highly convex, with the front expanded, and having the general form characteristic of the hypostomes of the Solenopleuridae.

Thorax unknown except for individual segments, and one incomplete example. The pleura have a well-impressed groove and end in a sharp point. At least one segment has a curved spine on the axial line; but it is not known which segment this is.

Pygidium rather convex, especially the axis, with a smooth surface. The axis has 6 regular segments and an additional terminal segment which sometimes shows faint traces of further segmentation. There are 5 ribs on the pleural lobes. The border is flat and of average width. The axis extends all the way to the rear edge of the shield, separating the pleural lobes at the rear.

The holotype is a cranidium, No. 56918a in the Princeton University collection. Paratypes are Nos. 56919b-p, 56920-56932, 56934, 56938, 56939, 56941-56960, 56962-56965, 56973, 56975, 56978-56980, 56983, 56984, 56990-56992, 56997, 56998, 57000, 57001, 57002b, 57003, 57006, 57007, 57012, 57013, 57025, 57029, 57031, 57036-57039, 57040, 57043, 57044, 57046, 57047, 57049, 57051, 57053, 57092, 57223, 57272, 57458, 57496, 57550, 57551, 57601, 57602, 57609, 57610 and 80369 in the Princeton collection, 16236 in the collection of the Wagner Free Institute of Science, 15884-15893 in the collection of the Academy of Natural Sciences of Philadelphia, and 10674-10679 in the collection of the Geological Survey of New Jersey. Tophomeotypes have also been placed in the United States National Museum and in the American Museum of Natural History.

Occurrence. In a finely crystalline black limestone bed of the Limeport formation in the southern quarry at Limeport. This species has been found only in the lower beds of the section exposed on the north wall of this quarry, beneath the disconformity and the overlying intraformational conglomerate which are present in that section. *Welleraspis* is abundant in one of these beds, and this bed and those associated with it below the disconformity are therefore called the *Welleraspis lata* beds. This species also occurs in the quarry of the New Hope Crushed Stone and Lime Company, 2 miles northwest of New Hope.

Discussion. Young cranidia of this species have the glabella relatively narrower than do adult cranidia, and the young free cheeks are narrower than the adult ones. In this respect the young cranidia of this species resemble adult cranidia of *Welleraspis jerseyensis* (Weller), a species found in beds of the lower part of the Kittatinny formation at Carpentersville, New Jersey, some miles northeast of Limeport (Howell, 1945) which may therefore be a somewhat older species than *Welleraspis lata.* In general, because of its relatively wider glabella, the cranidium of *W. lata* looks shorter and wider than the cranidium of *W. jerseyensis,* although one of the 3 cotypes of *W. jerseyensis* has a shorter glabella than the other

two and thus approaches *W. lata* in form. The glabellar furrows of *W. lata* are also a little more deeply impressed than are those of *W. jerseyensis,* and the occipital spine of *W. lata* tapers a little more rapidly than does that of *W. jerseyensis. W. lata* is also larger than *W. jerseyensis.* The glabella of *W. lata* is, on the other hand, not as wide as the glabella of *W. newfoundlandensis* Lochman, a species found in the *Cedaria* zone of Newfoundland. The glabella is longer in proportion to its width, less tapering, and more bluntly truncated in front than that of the cranidium from the Warrior limestone of central Pennsylvania that was identified by Tasch (1951, p. 303) as "*Welleraspis* cf. *newfoundlandensis* Lochman."

There is much individual variation in different cranidia of *Welleraspis lata* in the depth of the anterior glabellar furrow, in the thickness and convexity of the border, and in the distance between the border and the front of the glabella. If one had available for study only a few specimens that had such a range of variation he might suspect that he had representatives of two distinct forms. But in a series of hundreds of specimens there are represented all gradations between the two extremes. It is possible that these differences are due to sexual characters.

In some respects the various species of *Welleraspis,* and especially *W. lata,* remind one of species of the late medial Cambrian Solenopleurid genus, *Albansia,* especially of *Albansia pusilla* Howell, of the late medial Cambrian St. Albans formation of Vermont; but in *Albansia* the glabella is less quadrate than in *Welleraspis* and the fixed cheeks are only very narrowly confluent in front of the glabella. Also, *Albansia* lacks the long occipital spine of *Welleraspis. Welleraspis* may, however, be descended from *Albansia* or some closely related genus.

Professor Franco Rasetti has suggested to the writer that *Welleraspis* should probably be included in the older genus *Lonchocephalus,* which it resembles in some ways. However, a comparison of examples of the genotype of *Welleraspis, W. jerseyensis* (Weller), with a specimen of the genotype of *Lonchocephalus, L. chippawaensis* Owen, from the Eau Claire member of the Dresbach formation at Colfax, Wisconsin, in the Princeton University collection (No. 72236) causes the writer to agree with Kobayashi, who erected the genus *Welleraspis,* and C. Lochman, who assigned her Newfoundland species, *newfoundlandensis,* to it, that *Welleraspis* is a valid genus. Although it agrees with *Lonchocephalus* in most of its characters, *Welleraspis* differs from that genus in the shape of the glabella which is quadrate in form, whereas the glabella of *Lonchocephalus* tapers forward and is evenly rounded at the front. The front end of the glabella of *Welleraspis* is truncated, the front edge parallel with the occipital furrow. The two genera would, however, appear to be rather closely related and may in Dresbachian times have represented two parallel lines of evolution from a common ancestor of late medial Cambrian age.

Welleraspis also resembles Rasetti's (1944) Quebec genus, *Quebecaspis,* in the general shape of the cranidium; but the glabella of *Quebecaspis* is somewhat tapering, while in *Welleraspis* it is quadrate in shape, and *Quebecaspis* has only a slender occipital spine, whereas *Welleraspis* has a stout spine. *Quebecaspis* is believed to be a Dresbachian genus, and it and *Welleraspis* are probably closely related.

Welleraspis humilis Howell, n. sp.

(Pl. 3, fig. 2)

Known only from a single incomplete cranidium, which resembles the cranidium of *Welleraspis lata* in general form, but is less convex and has a smooth, not a tuberculate, exoskeleton.

This holotype specimen is No. 56887 in the Princeton collection.

Occurrence. In a fine-grained black limestone of the Limeport formation 2 miles northwest of New Hope.

Discussion. The beds in which this species was found are probably somewhat different in age from those in the southern quarry at Limeport that contain *Welleraspis lata,* for they have yielded several species not found with *W. lata* at the Limeport quarry, as will be noted on a later page. *W. humilis* is probably a younger species than *W. lata.*

Genus **Talbotina** Lochman (1938)

Talbotina pennsylvanica Howell, n. sp.

(Pl. 3, figs. 3-5, fig. 8 part)

Cranidium small, of average convexity, with both glabella and fixed cheeks moderately convex. The glabella is rather short and wide, its sides are parallel, and it is broadly rounded in front. There are two pairs of very faint glabellar furrows. The palpebral lobes are small and lie opposite the middle of the glabella. The ocular ridge is poorly developed. Each fixed cheek is about half as wide as the glabella at the point where the palpebral lobe is situated. The fixed cheeks are confluent in a fairly narrow band in front of the glabella. They are moderately prolonged laterally at the genal angles. The border is convex and is as wide as the confluent parts of the fixed cheeks in front of the glabella. The dorsal, marginal, and occipital furrows are well-developed. The occipital ring is rather wide and bears a small, short, spine. The surface of the exoskeleton appears to have been smooth.

Free cheeks have convex borders and short, pointed, genal spines.

Hypostome convex, only a little expanded at the front, and tapering to an evenly-rounded end, so that the whole plate is subtriangular in shape.

Thorax known only from fragments of pleura. These pleura have a well-developed groove which terminates at some distance from the end of the pleuron.

Pygidium with a highly convex axis composed of 5 regular annulations and a wider end segment. Four ribs on each pleural lobe and a rather wide, flat, border.

The holotype, a cranidium, is No. 56865a in the Princeton collection, and paratypes are Nos. 56865k, 56865l, 56865n-z, 56865a, 56865a″, 56866, 56871b, 56872b, 56874, 56876, 56877, 56878b, 56879, 56880b, 56881-56884, and 56887e.

Occurrence. In fine-grained black limestone of the Limeport formation in the southern quarry at Limeport. This species has been found in this

quarry only in beds which lie stratigraphically above those which hold *Welleraspis lata*—that is, in the beds above the disconformity and the intraformation conglomerate that overlie the beds containing *Welleraspis lata*. One specimen of *Talbotina pennsylvanica* was also collected at a locality west of New Hope, where it was associated with *Lingulella rugosa*. Because *T. pennsylvanica* is one of the commonest trilobites in the beds above the disconformity in the southern quarry at Limeport, these upper beds are called the *Talbotina pennsylvanica* beds.

Discussion. This little trilobite would seem to be referable to the genus *Talbotina*, which has been reported heretofore only from the *Cedaria* zone of the Petit Jardin formation of western Newfoundland and the *Cedaria* zone of the Pilgrim formation of Montana. The cranidium of *T. pennsylvanica* differs from that of *Talbotina degrasensis* Lochman and *T. solitaris* Lochman, of Newfoundland, and from that of *T. jeweli* Lochman, of Montana, the only other described species of the genus, in that its glabella is parallel-sided, not gently tapering. The pygidium of *T. pennsylvanica* differs from that of *T. degrasensis* in having a larger number of annulations in the axis and one more segment in the pleural lobes: it differs from the pygidium of *T. jeweli* in being longer in proportion to its width, and more convex, and in having one more annulation in the axis.

The pygidium of *Talbotina* is not that of a typical Solenopleurid, and it is possible that this genus does not belong in the Solenopleuridae, but should be placed in some other family or have a new family erected for it. Lochman, who erected the genus, compared it with *Weeksina*, which is probably a genus of the Asaphiscidae; but the writer doubts whether *Talbotina* belongs in the Asaphiscidae. *Talbotina* does resemble *Lonchocephalus* and probably belongs in the same family with that genus. In their memoir on the early late Cambrian faunas of central Montana Lochman and Duncan did not assign *Talbotina* to any family.

Talbotina aff. degrasensis Lochman

(Pl. 3, fig. 6)

Known only from two incomplete cranidia, which differ from the cranidia of *Talbotina pennsylvanica* in being larger, in having a tapering glabella, and in having the confluent portion of the fixed cheeks, in front of the glabella, much wider. The cranidium of *T.* aff. *degrasensis* is about 5 mm. long, and the confluent portion of the fixed cheeks measures ¾ mm. in the direction of the long axis of the cranidium. The corresponding measurements in an average adult cranidium of *T. pennsylvanica* are 3 mm. and ⅓ mm.

The specimens of this trilobite are Nos. 56856 and 57085 in the Princeton collection.

Occurrence. One of the specimens of *Talbotina* aff. *degrasensis* is from a light-gray limestone of the Limeport formation 2 miles northwest of New Hope. The other specimen was found in a dark-gray limestone of the same formation 2½ miles northwest of New Hope.

Discussion. The fauna of which this trilobite is a member is probably of the same age as the one in the *Talbotina pennsylvanica* beds above the disconformity in the southern quarry at Limeport. *T.* aff. *degrasensis* approaches *T. degrasensis* Lochman, of the *Cedaria* zone of the Petit Jardin formation of western Newfoundland, and *T. jeweli*, of the *Cedaria* zone of the Pilgrim formation of Montana, in the width of the confluence of the fixed cheeks in front of the glabella; but this width is even greater in *T.* aff. *degrasensis* than it is in these species. *T.* aff. *degrasensis* is smaller than *T. jeweli*, but is about the same size as *T. degrasensis*.

Talbotina clarae Howell, n. sp.

(Pl. 3, fig. 7)

The cranidium of this species resembles that of *T. pennsylvanica* in that the sides of its glabella are nearly parallel; but it is larger than the cranidium of that species, and in the adult stage it has a relatively short glabella. The glabella of *T. clarae* is also rather bluntly truncated at the front. There are two pairs of incomplete glabellar furrows. The anterior pair is relatively lightly impressed. The posterior furrows are arcuate. The border is evenly, but not highly, convex. The dorsal furrow is well developed. The palpebral lobes are of medium size, and the ridge is very poorly developed. The occipital ring is of medium size, and there is a small occipital spine, which is a little larger than that of *T. pennsylvanica*. The fixed cheeks are a little more widely confluent in front of the glabella than they are in *T. pennsylvanica*. The glabella and fixed cheeks are of moderate convexity, and the test is very finely shagreened. In large cranidia faintly defined ridges run radially from the dorsal furrows forward across the confluent area of the fixed cheeks, between the glabella and the border.

Free cheeks moderately convex, with a rather long, narrow, spine and a somewhat convex border of moderate width. Surface shagreened.

Hypostome rather convex, with moderately wide, flat, flanges at the front and a narrow border at the rear end. Surface smooth.

Pygidium of the usual Solenopleurid type, with a rather convex axis and only moderately convex pleural lobes. The axis has six segments, the rear one of which is longer than the others and reaches the rear edge of the shield. There are 5 ribs on the pleural lobes, the rear one being very short. The ribs do not reach the edge of the shield, the border of which is flat and rather wide. These pygidia resemble those of *Welleraspis lata*, with which they are often associated, except that the border, which is not crossed by the ribs, is wider than it is in *W. lata*. The border is not so wide in young pygidia as it is in adult ones.

The holotype is No. 56977a in the Princeton collection. Paratypes are Nos. 56961a and b, 56977b, 57005, 57015a, 57018a, 57019a, 57022, 57024, 57042, and 57549.

Occurrence. In the finely crystalline, black limestone of the *Welleraspis lata* beds of the Limeport formation, in association with *Welleraspis lata*, in the lower part of the section exposed in the southern quarry at Limeport, below the disconformity.

Discussion. This species differs from the species of *Talbotina* described from Newfoundland by Lochman, *T. degrasensis* and *T. solitaris,* and from the Montana species, *T. jeweli,* in being smaller and in having a narrower and more nearly parallel-sided and bluntly truncated glabella. In these respects *T. pennsylvanica* is intermediate between *T. clarae* and the two Newfoundland species. *T. clarae* occurs in beds which are older than those holding *T. pennsylvanica* and are separated from them by a disconformity.

The specific name of this species is given in honor of the writer's wife.

Bucksella Howell, n. gen.

Trilobites with an almost parallel-sided or gently tapering glabella, which is rounded at the front, fixed cheeks clearly confluent in front of the glabella, a convex and upturned border, small palpebral lobes, and a well-developed occipital spine. The border is so convex that it has the appearance of being sharply upturned, although it is only partly so. The glabella and fixed cheeks are rather highly convex (the glabella and fixed cheeks sometimes have an almost bulbous appearance), and the sides of the cranidium are more or less bent downward. The pygidium is rather highly convex, especially the axis, which is annulated and its pleural lobes are directed diagonally backward at an angle of 45°, or somewhat less, with the median axis of the shield. The type species, *Bucksella brevis,* is described below. The genus is probably related to *Lonchocephalus* Owen. It and *Talbotina* are here assigned only tentatively to the family Solenopleuidae. They are very possibly descended from the medial Cambrian Solenopleuridae; but the genal spines of their free cheeks and certain other features indicate that they may ultimately have to be placed in some other family or families. *Bucksella* may not be properly referred to the Solenopleuridae; but the writer knows of no other family in which it may belong. It is probably related to *Piedmontia* and may belong in the same family with that genus, whatever that family may be. The writer knows of no species except those described here that are referable to *Bucksella.*

Bucksella is closely related to *Welleraspis,* but differs from that genus in having the glabella in the more typical species less quadrate in outline and more evenly rounded in front, in not having the front of the glabella as close to the border, and in having the fixed cheeks more widely confluent in front of the glabella and the border more definitely turned up, so that it rises above the confluent portion of the fixed cheeks. The two genera are connected by *Bucksella limeportensis* (described below), which comes very close to being a *Welleraspis,* since it has a more quadrate glabella than the more normal species of *Bucksella,* and the glabella is a little less tapering in its rounding at the front. *Welleraspis lata,* which appears to be in some ways an advanced type of *Welleraspis* since the front of the glabella almost touches the border, is found at Limeport below *Bucksella limeportensis.* Hence, its line would seem to have been evolving, before the time when *B. limeportensis* lived, independently of the *Bucksella* line. Consequently, it might seem desirable to include in *Welleraspis* the species here placed in *Bucksella.* The evidence appears, however, to indicate that there are two distinct evolutionary lines repre-

sented, and that we must have two genera for them. But, if *Bucksella limeportensis* were the only species of the *Bucksella* line known to us, we would be justified in assigning it to *Welleraspis*. *B. limeportensis* greatly resembles *Welleraspis jerseyensis* (Weller), the genotype of *Welleraspis,* but differs in having the fixed cheeks confluent in front of the glabella and in having a shorter glabella and deeper glabellar furrows.

Bucksella is in some ways intermediate between *Welleraspis* and *Lonchocephalus* (which also occurs in the Limeport formation), and all three genera in early Dresbachian times were probably contemporaneous descendants, in three different evolutionary lines, of a common ancestor. The species from the Warrior limestone of central Pennsylvania described by Tasch (1951, p. 300) as "*Lonchocephalus waddlei*" and "*Lonchocephalus swartzi*" resemble some of our species of *Bucksella* in general form, but are much larger and differ in some details from our species.

Bucksella limeportensis Howell, n. sp.

(Pl. 3, figs. 8-11; fig. 3 part)

Cranidium rather long, narrow and moderately convex. Glabella almost parallel-sided and very bluntly rounded in front, with two pairs of short furrows, the rear ones of which curve backward as they approach the median axis. Fixed cheeks rather narrow, not much extended at the genal angles, and confluent in a narrow convex band in front of the glabella. Palpebral lobes small. Ocular ridge not strongly developed. Dorsal, marginal, and occipital furrows well-impressed. At the anterior corners of the glabella the dorsal furrow is more deeply impressed than it is elsewhere, so that small pits are formed there. These pits are more clearly seen in peeled specimens than in unpeeled ones. Occipital ring prolonged into a spine which, with the occipital ring, is half as long as the glabella. Border convex and as wide as the part of the fixed cheeks where they are confluent in front of the glabella. The border is somewhat upturned, and the sides of the cranidium are rather sharply bent downward. The cranidium is covered with fine tubercles. Young cranidia have the glabella relatively narrower than do adult cranidia.

Free cheek with a convex, but not very wide, border and a narrow, short, sharply pointed, genal spine which is about half as long as the glabella.

Hypostome convex, with short extensions at the front end and a narrow border.

Thoracic segments deeply grooved.

Pygidium highly convex and rather narrow, with the axis, especially, convex at its rear end and divided into 5 annulations and a longer end segment. The pleural lobes slope rather steeply downward and have the same number of ribs as there are segments in the axis. The ribs are directed backward at an angle of about 45° to the axis. Only the rear portion of the border is preserved in the single known pygidium, and that portion is so narrow as to indicate that the border, as a whole, was not wide.

The holotype, a cranidium, is No. 56867a in the Princeton collection and paratypes are Nos. 56865b-j, 56865m, 56865b′, 56865b″, 56866, 56867b-d, 56868, 56871a, 56873, 56878a, 56880a, 56906c, 56914, 56916, 56935-56937, 56981, and 56982.

Occurrence. In fine-grained black limestone of the upper beds of the Limeport formation (above the disconformity) at Limeport in association with *Talbotina pennsylvanica.* This species has not been found in the beds below the disconformity, in which *Welleraspis lata* occurs. One specimen of *Bucksella limeportensis* was also collected from the fine-grained black limestone of the Limeport formation, which contained *Bucksella brevis* (described below), 2 miles northwest of New Hope.

Bucksella brevis Howell, n. sp.

(Pl. 4, fig. 1)

Cranidium similar to that of *Bucksella limeportensis,* but with a shorter glabella, which tapers a little more than does the glabella of that species, and with a more upturned border.

Free cheek wider than that of *B. limeportensis,* with a wider border and a thicker spine, which may also have been longer. The only specimens of free cheeks of *B. brevis* are incomplete, so that the full length of the spine cannot be determined. The border bears inosculating ridges and the rest of the cheek is finely tuberculate.

Hypostome long, narrow, and convex, flaring only a little at the front, and with a marginal band and thread-like raised border along its rear edge and sides.

Pleura deeply grooved.

Pygidium similar to that of *B. limeportensis* except that it is shorter and less convex and has only 3 annulations and a terminal segment and a corresponding number of ribs on the pleural lobes. The pleural lobes are narrow and the border is of moderate width.

The holotype, a cranidium, is No. 56886 in the Princeton collection and paratypes are Nos. 56888b, 56892-56896, 56897b, 56900, 56903, 56909, 56910, 56915, and 56916.

Occurrence. In finely crystalline black limestone of the Limeport formation in a quarry 2 miles northwest of New Hope in association with *Welleraspis humilis.* Also in a dark-gray limestone of the same formation 2½ miles northwest of New Hope, in association with *Talbotina rara.*

Discussion. The exact age of the beds holding this species is not known; but the beds are probably of about the same age as the *Talbotina pennsylvanica* beds above the disconformity in the southern quarry at Limeport.

Bucksella solitaria Howell, n. sp.

(Pl. 4, figs. 2-4)

Cranidium 6 mm. long and 6 mm. wide and a little more convex than in the other species of *Bucksella.* The fixed cheeks are a little more widely

confluent in front of the glabella than is the case in *B. brevis*, and the glabella of *B. solitaria* is relatively longer and less tapering than that of *B. brevis*. The glabella is almost parallel-sided and is more evenly rounded in front than it is in *B. limeportensis*, but it is relatively a little narrower than the glabella of that species. The exoskeleton is finely shagreened.

Free cheeks similar to those of *B. limeportensis*. There are fine, raised, anastomosing lines on the rather highly convex border.

Hypostome narrow and fairly highly convex, with narrow, flat anterior arms and a narrow, raised, border.

Thoracic segments with deeply grooved pleura, the grooves reaching almost to the ends of the pleura, which are cut off diagonally and roundly, so that the pointed extremity is directed backward.

Pygidium with a highly convex axis which reaches the rear end of the shield and is clearly divided into 6 segments, the last of which is longer than the others and is divided into 2 annulations. The pleural lobes, which are less convex than the axis, have 4 ribs, (there is sometimes a trace of a 5th rib) each of which bears a shallow groove and a small ungrooved area behind the posterior rib and beside the rear lobe of the axis. The narrow border of the shield is almost flat.

The holotype is No. 57002a in the Princeton collection. Paratypes are Nos. 56969a, 56985-56989, 56997, 56999a, 57008, 57016, 57020, 57021, 57027, 57028, 57044a-c, 80376, 80379, and 80388.

Occurrence. In fine-grained black limestone of the *Welleraspis lata* beds of the Limeport formation in the southern quarry at Limeport, below the disconformity, and in the *Welleraspis lata* beds in the New Hope Crushed Stone and Lime Company quarry 2 miles northwest of New Hope.

Discussion. This species is older than *Bucksella limeportensis*, which is found above the disconformity at Limeport, and is probably the oldest of the known species of *Bucksella*. It is intermediate in its characters between *B. limeportensis* and *B. brevis*.

Bucksella longa Howell, n. sp.

(Pl. 4, figs. 5, 6)

Cranidium similar to that of *B. limeportensis*, but longer in proportion to its width and having a longer glabella. The area between the front of the glabella and the marginal furrow is also much more convex in this species than it is in *B. limeportensis*, and the whole front end of the shield is somewhat turned down, so that the border itself does not appear to be so upturned. The glabellar furrows are faint.

The free cheeks are similar to those of *B. limeportensis*. Although marked with inosculating lines on their borders, they do not bear tubercles as those of *B. brevis* do, and the genal spine appears to have been shorter than it was in that species.

The hypostome and thorax are unknown.

The pygidium resembles that of *B. limeportensis,* but is not so highly convex and is not so sharply bent downward on the sides. It is narrower and more convex than the pygidium of *B. brevis,* and the pleural lobes are directed more toward the rear than they are in that species.

The holotype is No. 56887b in the Princeton collection, and paratypes are Nos. 56887c, 56888b, 56906a, 56908, 56911, 56913, 56917.

Occurrence. In finely crystalline black limestone of the Limeport formation 2½ miles northwest of New Hope, and in a similar limestone beside a lane running along a stream from an old mill to the public road, 2½ miles northwest of New Hope.

Discussion. The cranidium of this species can be distinguished from those of *B. limeportensis* and *B. brevis* by its long glabella and the convexity of the area immediately in front of the glabella.

Genus **Lonchocephalus** Owen (1852)

Lonchocephalus pennsylvanicus Howell, n. sp.

(Pl. 4, fig. 7)

Known only from a single cranidium, of which the glabella alone is well-preserved. This glabella is 5 mm. long, 4 mm. wide at the rear, and 2½ mm. wide at the front. It is moderately convex and its anterior end is evenly rounded. It has two pairs of incomplete furrows, which are directed backward at an angle of about 45° to the dorsal furrow. The anterior pair is not strongly-developed, but the posterior pair is deeply incised. The occipital furrow is moderately well-developed, and the occipital ring is of medium width. Whatever occipital spine was present has been broken off from our single cranidium.

This holotype cranidium is No. 56891 in the Princeton collection. Another cranidium that may belong to this species, discussed below, is No. 56907.

Occurrence. In the fine-grained black limestone of the *Talbotina pennsylvanica* beds of the Limeport formation in the southern quarry at Limeport, above the disconformity, in association with *Talbotina pennsylvanica, Bucksella limeportensis,* and *Lingulepis limeportensis.* An incomplete cranidium which may be referable to this species was found in beds of the Limeport formation containing *Bucksella brevis* 2 miles northwest of New Hope. It is 6 mm. long and larger than the Limeport specimen and has tubercles on its surface. Because this cranidium is so incomplete, and because the surface of the holotype cranidium of *Lonchocephalus pennsylvanicus* is weathered so that we cannot determine whether it had tubercles on its surface, we cannot be certain whether this second cranidium belongs in *L. pennsylvanicus* or not. However, the fact that *Bucksella limeportensis,* which occurs with *L. pennsylvanicus* at Limeport, occurs also with this second *Lonchocephalus* cranidium northwest of New Hope, makes it seem probable that the latter is referable to *L. pennsylvanicus.*

Lonchocephalus parvulus Howell, n. sp.

(Pl. 4, fig. 8)

Known only from 3 cranidia and 2 occipital spines that have been broken away from their cranidia. The glabellas of these cranidia resemble the glabella of *Lonchocephalus pennsylvanicus* in general form, but are smaller (only 1½ and 3½ mm. long), more tapering (wider at the rear), and their two pairs of glabellar furrows are less deeply incised. Their surfaces are smooth. The surfaces of the cranidia are also smooth. The occipital spines are remarkably long, as long as the glabellas. The shorter of the two isolated spines, which probably belonged to a cranidium of about the same size as that of the holotype is 2½ mm. long. The other isolated spine, which must have belonged to a somewhat larger cranidium and has the tip broken off, must have been 3½ mm. long. Both spines appear to have been straight rather than curved.

The holotype cranidium is No. 56912a in the Princeton collection. The other (paratype) cranidia are Nos. 56897 and 56940. The paratype occipital spines are Nos. 56898 and 56899.

Occurrence. In fine-grained black limestone of the Limeport formation 2 miles northwest of New Hope, in association with *Bucksella brevis, B. longa, B. limeportensis, Welleraspis humilis, Talbotina rara, Coosia parva* (described below), and *Lingulella rugosa,* and in finely crystalline gray limestone, probably of the same age, northwest of New Hope.

Discussion. This species is remarkable for the great length of its occipital spine, which is long even for a *Lonchocephalus. L. bunus* Walcott, from the Upper Cambrian of Minnesota, resembles our species in its small size, in the general form of its glabella, and in the weakness of its glabellar furrows; but, although its occipital spine is long, it is not nearly so long as that of *L. parvulus.*

Lonchocephalus angustus Howell, n. sp.

(Pl. 4, fig. 9)

Glabella small (1½ mm. long and 1¼ mm. wide), tapering, and rather acutely rounded in front, so that it has a subtriangular shape. The two pairs of glabellar furrows are deeply impressed, and the rear one curves inward and backward from the dorsal furrow. Dorsal and occipital furrows moderately deep. Glabella and fixed cheeks moderately convex. Test smooth.

The holotype cranidium is No. 57017a in the Princeton collection, paratype cranidia are Nos. 57048, 57546-57548, 57552, and 57594, and paratype occipital spines are Nos. 57009a and 57050a.

Occurrence. In fine-grained black limestone of the *Welleraspis lata* beds of the Limeport formation below the disconformity in the southern quarry at Limeport.

Discussion. Lonchocephalus angustus resembles *L. pennsylvanicus* in the general shape of its glabella and the depth of its glabellar furrows;

but the glabella of *L. angustus* is somewhat narrower than that of *L. pennsylvanicus,* and *L. angustus* is a smaller species. It is possible that *L. angustus,* which is the older of the two species, was the ancestor L. *pennsylvanicus.* The cranidium of *L. angustus* is much smaller than that of a large specimen of *L. parvulus,* and its glabella is relatively narrower than the glabella of that species. All of our species of *Lonchocephalus* are much smaller than the species of *Lonchocephalus* described by Tasch (1951) from the Warrior limestone of central Pennsylvania.

Family ANOMOCARIDAE

Genus **Coosia** Walcott (1911)

Coosia parva Howell, n. sp.

(Pl. 4, figs. 10, 11)

Known only from a single pygidium and one free cheek.

The pygidium is small (4 mm. long and 6 mm. wide), with the axis reaching almost all the way to the rear edge of the shield. The axis rises only a little above the general level of the shield and shows almost no visible traces of segmentation. Each pleural lobe is only a very little convex and is about as wide as the widest part of the axis. The rear edge of the shield is slightly indented at the axial line. The surface of the test is smooth. Only the faintest indications of ribs can be seen on the pleural lobes.

The free cheek is of average width for a *Coosia* and is only slightly convex. It has a rather narrow border and a short, but deeply indented, eye notch. The front edge is diagonal because of the flare in the brim of the cranidium that is characteristic of *Coosia.* The rear end of the single free cheek available is broken off, so that the length of the genal spine is not known.

The holotype pygidium is No. 56888a in the Princeton collection. The paratype free cheek is No. 56889.

Occurrence. In finely crystalline black limestone of the Limeport formation 2 miles northwest of New Hope.

Discussion. This species is distinguished from the other known species of *Coosia* by its small size and the long axis on its pygidium.

Genus **Coosella** Lochman (1936)

Coosella lata Howell, n. sp.

(Pl. 5, fig. 1)

Only the single imperfect holotype cranidium is known, and it shows only the right half of the anterior portion of the shield. The glabella and fixed cheeks are moderately convex. The ocular ridge and dorsal furrow are well-developed. The fixed cheeks are narrowly and convexly confluent in front of the glabella and are rather wide where the ocular ridge crosses them. The border is convex and fairly sharply upturned, and the marginal

furrow is well-developed. The exoskeleton is covered with fine granules. The holotype cranidium is No. 56994a in the Princeton collection.

Occurrence. In fine-grained black limestone of the *Welleraspis lata* beds of the Limeport formation below the disconformity in the southern quarry at Limeport.

Discussion. This species somewhat resembles *Coosella helena* Lochman, of the *Cedaria* zone Petit Jardin formation of western Newfoundland; but our species has relatively wider fixed cheeks than does the Newfoundland form, and these fixed cheeks are more narrowly confluent in front of the glabella. If our single cranidium is that of an adult individual, *C. lata* was also a smaller species than *C. helena.* It is also smaller than the species of *Coosella* described by Tasch (1951, pp. 289-291) from the Warrior limestone of central Pennsylvania and differs from those species in other ways.

Family LEIOSTEGIIDAE

Genus **Genevievella** Lochman (1936)

Genevievella pennsylvanica Howell, n. sp.

(Pl. 5, fig. 2)

Only the single, imperfect, holotype cranidium is known, and it shows only the glabella and one fixed cheek. The glabella, which tapers forward and is evenly rounded in front, is 6 mm. long and 5 mm. wide and is rather highly convex. It bears 2 pairs of very lightly impressed furrows. The rear, and longer, furrows are arcuate. The fixed cheek is also highly convex and about half as wide as the glabella, and the dorsal furrow is deep. The posterior limb is narrow and long, and the marginal furrow on its rear portion deep. The palpebral lobe is of medium size, the ocular ridge low and narrow. The test is covered with rather widely spaced large tubercles, between which are scattered a few smaller tubercles. The other features of the shield are not preserved in this cranidium.

Ths holotype is No. 56971a in the Princeton collection.

Occurrence. In the fine-grained black limestone of the *Welleraspis lata* beds of the Limeport formation in the lower part of the southern quarry at Limeport, below the disconformity.

Discussion. Genevievella pennsylvanica resembles *G. tumida* Lochman, of the early Dresbachian (*Cedaria* zone), Bonneterre formation of Missouri, but differs from that species in being somewhat larger and in having narrower fixed cheeks and a relatively longer glabella. The glabella of *G. tumida* is 5½ mm. long and 7 mm. wide, while that of *G. pennsylvanica* is 6 mm. long and only 5 mm. wide. *G. pennsylvanica* appears also to differ from the three species of *Genevievella* described by Tasch (1951, pp. 292-294) from the Warrior limestone of central Pennsylvania.

Trilobite, genus and species undetermined

(Pl. 5, fig. 3)

The distal portion of the pleuron of a trilobite which was much larger than those described above was found in association with *Lingulepis pinnaformis* in the Limeport formation 2 miles northwest of New Hope. This pleuron, which is 2½ mm. wide, is nearly flat and bears a shallow groove. Its end is bluntly pointed. The genus to which it belongs cannot be determined until additional examples of the species have been discovered.

The specimen is No. 56890 in the Princeton Collection.

Occurrence. In fine-grained, thin-bedded gray limestone of the Limeport formation 2 miles northwest of New Hope.

Discussion. As this specimen is too imperfect for generic determination or specific description, no name is here given, although it is probably a representative of an undescribed species.

Class CRUSTACEA

Superorder BRANCHIOPODA

Order CONCHOSTRACA

Family INDIANITIDAE

Genus **Indianites** Ulrich and Bassler (1931)

Indianites minutus Howell, n. sp.

(Pl. 5, fig. 4)

Known only from the holotype left valve.

Carapace very small (1½ mm. long and 1¼ mm. wide), rather highly convex (¾ mm. high), subovoid in form, with the anterior end a little restricted at the bottom in the arc of its curve. Hinge line straight and 1¼ mm. long. The widest portion of the valve lies below the posterior end of the hinge, and the rear edge of the valve curves backward, as well as downward, from the rear end of the hinge. No distinct node can be seen, but a trace of one is just visible slightly above the middle of the valve. The surface of the valve is not well-preserved, but it appears to have been punctate.

The holotype is No. 57014 in the Princeton collection.

Occurrence. In fine-grained black limestone of the *Welleraspis lata* beds of the Limeport formation, in the lower part of the section exposed in the southern quarry at Limeport, below the disconformity.

Discussion. The valve of this tiny species somewhat resembles in outline that of *Indianites matthewi* (Ulrich and Bassler), of the late medial Cambrian *Paradoxides* beds of New Brunswick; but it is wider in proportion to its length, and the rear end does not curve as far back from the rear end of the hinge in that species. *I. matthewi* is also a much larger species than *I. minutus*. Its valve is 4 mm. long. *I. matthewi* is a some-

what older species than *I. minutus* and may have been an ancestor of the latter.

Indianites perpusillus Howell, n. sp.

(Pl. 5, figs. 5, 6)

Carapace very small (½ mm. long and ⅓ mm. wide), moderately convex, ovoid in outline, with the anterior end a little restricted at the bottom in the arc of its curve. The hinge line is difficult to see in the single known specimen; but it appears to be rather short, with the posterior edge of the valve curving for some distance back and away from its rear end. No node can be observed on any of the known specimens. As far as can be determined, the surface of the valve was smooth or finely punctate.

The holotype, a right valve, is No. 57026a in the Princeton collection. Paratypes are Nos. 57030 and 57033a. No. 57033a is a left valve.

Occurrence. In fine-grained black limestone of the *Welleraspis lata* beds of the Limeport formation in the lower part of the section exposed in the southern quarry at Limeport, below the disconformity.

Discussion. This is the smallest known species of *Indianites.* It is so much smaller than all of the other known species of the genus that it is clearly distinct from them on size alone. Also, it differs from all other species of *Indianites* in outline. It is longer in proportion to its width than *I. minutus,* and is only ⅓ the size of that species.

Indianites limeportensis Howell, n. sp.

(Pl. 5, fig. 7)

Known only from two right valves.

Carapace 1 mm. long and ½ mm. wide, ovoid in outline, and moderately convex. The hinge line is difficult to see, but it appears to have extended for only about half the length of the valve. Behind it the rear edge of the valve curves backward and downward, then forward and somewhat upward to the front end of the valve, which is narrower than the rear end. No distinct node can be seen on the single known specimen. The surface of the valve appears to have been smooth or very finely punctate.

The holotype, a right valve, is No. 57054 in the Princeton collection. The paratype is No. 57468.

Occurrence. In fine-grained black limestone of the *Welleraspis lata* beds of the Limeport formation in the lower part of the section exposed in the southern quarry at Limeport, below the disconformity.

Discussion. This species is intermediate in size between *I. minutus* and *I. perpusillus,* and its carapace is more elongate than the carapaces of those species. Its form somewhat resembles that of the Swedish species, *I. anderssoni* (Wiman), but is much smaller. The available evidence would seem to indicate, however, that all four of these species are of nearly the same age and that they all occur in beds of the Dresbachian stage.

THE AGE OF THE FAUNAS

The brachiopods, trilobites, and conchostracans described above indicate that several different Dresbachian (early Late Cambrian) faunas or faunules are represented by the fossils in the beds of the Limeport formation in Bucks County. All of them are probably faunas or faunules of the early Dresbachian *Cedaria* zone, although one or more of them may be so high in that zone as to approach the base of the overlying medial Dresbachian *Crepicephalus* zone.

Four faunas or faunules appear to be represented. These are the *Welleraspis lata* faunas or faunule, which is found in the beds *below* the disconformity in the southern quarry at Limeport; the *Talbotina pennsylvanica* fauna or faunule, in the beds *above* the disconformity in that quarry; the fauna or faunule whose commonest species is *Bucksella brevis* that is present in beds about 2½ miles northwest of New Hope; and the fauna or faunule whose commonest species is *Lingulepis pinnaformis,* found 2 miles northwest of New Hope. These faunas or faunules will be referred to in the following discussion as the *Welleraspis lata* fauna, the *Talbotina pennsylvanica* fauna, the *Bucksella brevis* fauna, and the *Lingulepis pinnaformis* fauna.

The *Welleraspis lata* fauna contains, in addition to *Welleraspis lata,* the trilobites *Pemphigaspis franklini, Talbotina clarae, Bucksella solitaria, Lonchocephalus angustus, Coosella lata,* and *Genevievella pennsylvanica,* the conchostracans *Indianites minutus, I. limeportensis,* and *I. perpusillus,* and the brachiopod, *Lingulella modesta.*

The *Talbotina pennsylvanica* fauna contains, in addition to *Talbotina pennsylvanica,* the trilobites *Bucksella limeportensis* and *Lonchocephalus pennsylvanicus* and the brachiopod *Lingulepis limeportensis.*

The *Bucksella brevis* fauna contains, in addition to *Bucksella brevis,* the trilobites *Bucksella longa, B. limeportensis, Welleraspis humilis, Talbotina* aff. *degrasensis, Lonchocephalus parvulus, Coosia parva,* and the brachiopod, *Lingulella rugosa.*

The *Lingulepis pinnaformis* fauna contains *Lingulepis pinnaformis, Lingulepis limeportensis, Lingulella* aff. *prima,* and the unidentified trilobite whose pleuron is described on an earlier page.

In addition to these four faunas there are present in the Limeport formation at least two floras of calcareous algae—the flora whose three known species are *Cryptozoön fieldi* Fenton and Fenton, *Dolatophycus expansus* Fenton and Fenton, and *Archaeozoön undulatum* (Bassler) that is found in the northern quarry at Limeport, apparently stratigraphically above the *Talbotina pennsylvanica* fauna, and a flora that contains an undescribed large, dome-shaped calcareous alga.

The ages of the *Bucksella brevis* fauna and the *Lingulepis pinnaformis* fauna relative to those of the *Welleraspis lata* fauna and the *Talbotina pennsylvanica* fauna are not known; but the presence of *Bucksella limeportensis* in both the *Talbotina pennsylvanica* fauna at Limeport and the *Bucksella brevis* fauna 2 miles northwest of New Hope would seem to indicate that these two faunas are not greatly different in age; and the presence of *Lingulepis limeportensis* in both the *Talbotina pennsylvanica* fauna and the *Lingulepis pinnaformis* appears to indicate that these two faunas are of about the same age.

Like some of the other Dresbachian faunas of North America, those found in Bucks County are remarkable for the small size of most of their trilobites. Genera, none of whose species ever grew large, seem to have been characteristic of this age. The small size of these fossils does not appear to have been due to conditions that were unfavorable for trilobites, but only to the fact that genera whose species were small were most abundant in the seas of that time.

The oldest of these four faunas, the *Welleraspis lata* fauna, includes five genera of trilobites—*Welleraspis, Talbotina, Lonchocephalus, Coosella,* and *Genevievella*—that are found elsewhere in the lower Dresbachian *Cedaria* zone. The *Welleraspis lata* beds, therefore, probably lie in that zone, although two of these genera, *Lonchocephalus* and *Coosella,* also occur in the overlying *Crepicephalus* zone elsewhere in North America. One of the genera present in the *Welleraspis lata* fauna of Bucks County, *Pemphigaspis,* appears to have been found elsewhere in North America only in beds of the *Crepicephalus* zone, and it has therefore been looked upon up until now as an index fossil of that zone; but it apparently occurs in the *Cedaria* zone also. Two of the other trilobite genera represented in the *Welleraspis lata* beds, *Lonchocephalus* and *Coosella,* also have representatives in the *Crepicephalus* zone of other parts of this continent; and it is therefore probable that the *Welleraspis lata* beds are high in the *Cedaria* zone.

If the *Welleraspis lata* beds lie high in the *Cedaria* zone, the *Talbotina pennsylvanica* beds, which overlie them disconformably at Limeport, probably are very near the top of that zone; for, although one of the trilobite genera, *Talbotina,* that is present in them is known to occur in other regions only in the *Cedaria* zone, another, *Lonchocephalus,* is a characteristic genus of both the *Cedaria* zone and the *Crepicephalus* zone elsewhere in North America.

The *Bucksella brevis* fauna of Bucks County contains four genera of trilobites—*Welleraspis, Talbotina, Lonchocephalus,* and *Coosia*—that are characteristic of the *Cedaria* zone, and only one of these, *Lonchocephalus,* is known to range upward into the *Crepicephalus* zone; so that *Bucksella brevis* fauna probably belongs in the upper part of the *Cedaria* zone also. But just exactly what its stratigraphic position is relative to that of the *Welleraspis lata* fauna cannot be determined from the data now available. The presence of *Bucksella limeportensis* in both the *Bucksella brevis* beds and the *Talbotina pennsylvanica* beds would seem to indicate that the *Bucksella brevis* fauna is probably of about the same age as the *Talbotina pennsylvanica* fauna, and that it is, therefore, a little younger than the *Welleraspis lata* fauna.

Because of the absence of identifiable trilobites and our lack of knowledge of the limits of the stratigraphic ranges of the species of brachiopods present in the *Lingulepis pinnaformis* fauna, and because of the absence of trilobites and our lack of knowledge of the stratigraphic ranges of the calcareous algae in the algal floras, in Bucks County, the exact age of the *Lingulepis pinnaformis* fauna and of the algal floras cannot be determined at this time. The *Lingulepis pinnaformis* fauna is almost certainly Dresbachian and is probably of about the same age as the *Talbotina pennsylvanica* fauna, since the brachiopod, *Lingulepis limeportensis,* is present

in both faunas; and the algal flora in the northern quarry at Limeport is assumed to be younger than the *Talbotina pennsylvanica* fauna because it is found apparently stratigraphically above that fauna at Limeport. But how much younger than the *Talbotina pennsylvanica* fauna the algal flora at Limeport is we have no means of determining at present.

No trace of any fauna of the late Dresbachian *Aphelaspis* zone or of any Franconian (medial late Cambrian) fauna has been found in Bucks County or elsewhere in eastern Pennsylvania or northern New Jersey; and, if beds of late Dresbachian or of Franconian age were ever deposited in those regions, they must have been removed by erosion in Franconian times. Trempealeauian (late Late Cambrian) strata containing Trempealeauian faunas and floras are, however, known in both eastern Pennsylvania and northern New Jersey. No Trempealeauian fauna or flora has yet been found in Bucks County, however; and, if Trempealeauian beds were ever deposited there, they must have been eroded away.

No attempt will be made here to correlate the Limeport formation with other Dresbachian formations except to point out that it must be, at least in part, of about the same age as the Warrior formations of central Pennsylvania, the lower part of which holds a *Cedaria* zone fauna. Higher beds of the Warrior formation contain a *Crepicephalus* zone fauna and may be of the same age as the upper part of the Limeport formation. Furthermore, the Limeport formation is presumably of about the same age as the beds holding *Welleraspis jerseyensis* (Weller) at Carpentersville, New Jersey, which are in the lower part of the Kittatinny formation (Howell, 1945). The Upper Cambrian faunas of central Pennsylvania have been described by Wilson (1951) and Tasch (1951). The faunas described by Wilson were all of Franconian age, and were thus younger than our faunas. But the faunas described by Tasch were in part similar to ours, although no one of Tasch's species appears to be identical with any one of the faunas described above. Tasch's faunas all came from the Warrior limestone. The Limeport formation, from which our fossils were collected, must be of about the same age as at least a part of the Warrior formation, but just what part can not be determined at the present time.

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EXPLANATION OF PLATES

PLATE 1

FIGURE 1. *Lingulella modesta* Lochman. Dorsal valve. X 5. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56933a, Princeton Univ.

FIGURE 2. *Lingulella rugosa,* n. sp. Paratype ventral valve. X 8. *Bucksella brevis* beds, Limeport formation, northwest of New Hope, Pennsylvania. No. 56470, Princeton Univ.

FIGURE 3. *Lingulella rugosa,* n. sp. Holotype dorsal valve. X 4. *Bucksella brevis* beds, Limeport formation, northwest of New Hope, Pennsylvania. No. 56465, Princeton Univ.

FIGURE 4. *Lingulella rugosa,* n. sp. Paratype dorsal valve. X 9. *Bucksella brevis* beds, Limeport formation, northwest of New Hope, Pennsylvania. No. 56466a, Princeton Univ.

FIGURE 5. *Lingulella rugosa,* n. sp. Paratype dorsal valve, showing rugosity of shell. X 5. *Bucksella brevis* beds, Limeport formation, northwest of New Hope, Pennsylvania. No. 56468a, Princeton Univ.

FIGURE 6. *Lingulella* aff. *prima* (Hall). Dorsal valve. X 2. *Lingulepis pinnaformis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56847a, Princeton Univ.

FIGURE 7. *Lingulella* aff. *prima* (Hall). Dorsal valve. X 5. *Lingulepis pinnaformis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56847a, Princeton Univ.

FIGURE 8. *Lingulella* aff. *prima* (Hall). Ventral valve. X 3. *Lingulepis pinnaformis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56846a, Princeton Univ.

FIGURE 9. *Lingulepis pinnaformis* (Owen). Dorsal and ventral valves. X 1. Eau Claire formation, St. Croix Falls, Wisconsin. No. A987a, Princeton Univ.

FIGURE 10. *Lingulepis pinnaformis* (Owen). Ventral valve. X 2. Eau Claire formation, St. Croix Falls, Wisconsin. No. A987b, Princeton Univ.

FIGURE 11. *Lingulepis pinnaformis* (Owen). Ventral valve. X 3. *Lingulepis pinnaformis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56843, Princeton Univ.

FIGURE 12. *Lingulepis limeportensis,* n. sp. Holotype. Ventral valve. X 3. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56416a, Princeton Univ.

FIGURE 13. *Lingulella limeportensis,* n. sp. Paratype dorsal and ventral valves. X 2. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56836, Princeton Univ.

PLATE 1

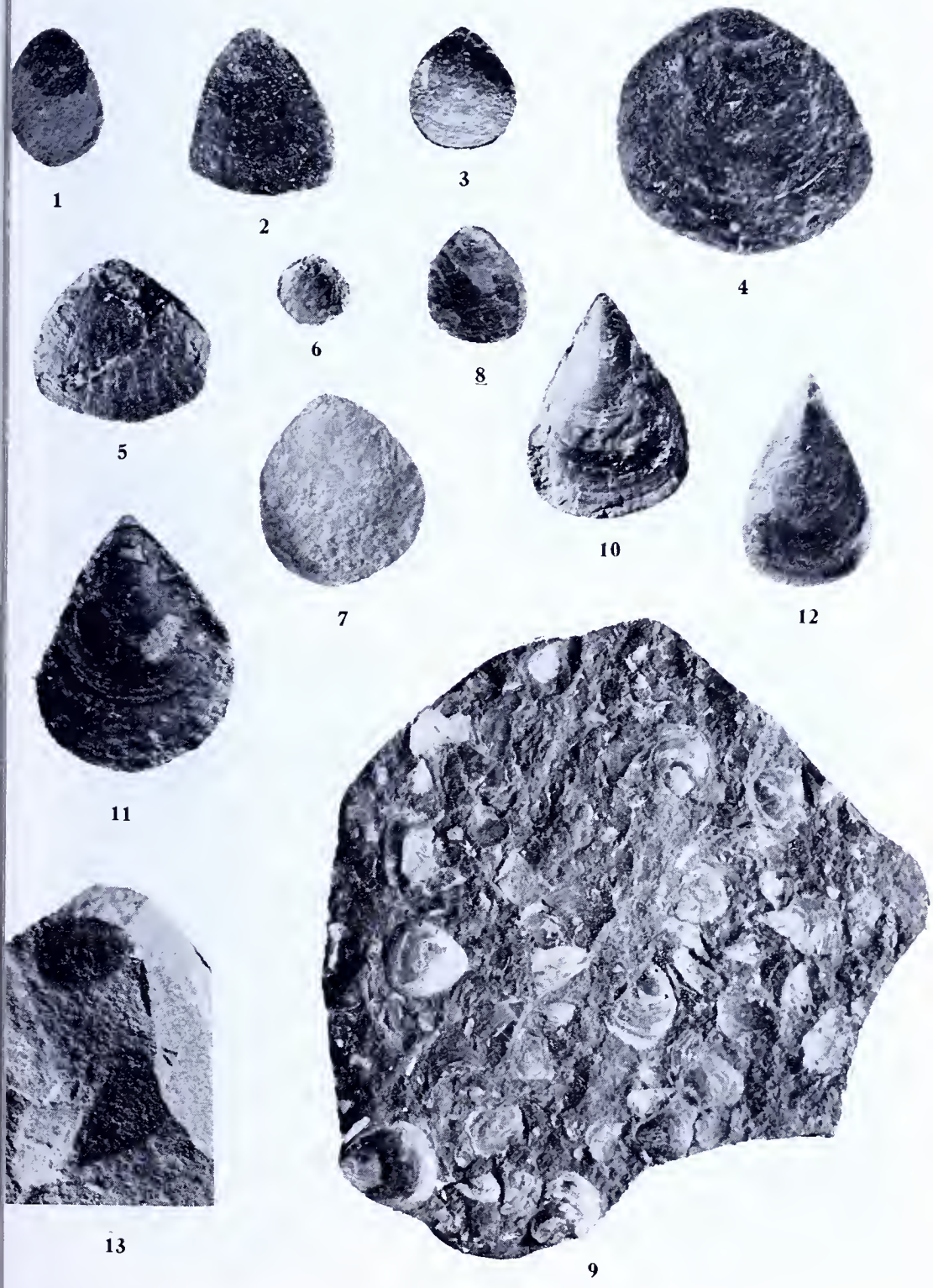

PLATE 2

1

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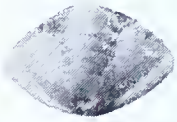

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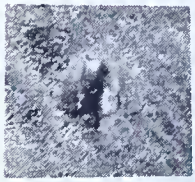

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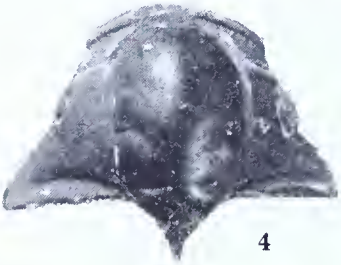

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Plate 2

Figure 1. *Pemphigaspis franklini,* n. sp. Holotype pygidium. X 7. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57010, Princeton Univ.

Figure 2. *Welleraspis lata,* n. sp. Holotype adult cranidium and paratype young cranidia. X 4. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56918, Princeton Univ.

Figure 3. *Welleraspis lata,* n. sp. Paratype cranidia. X 5. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57006, Princeton Univ.

Figure 4. *Welleraspis lata,* n. sp. Paratype cranidium. X 5. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56979, Princeton Univ.

Figure 5. *Welleraspis lata,* n. sp. Paratype young and adult cranidia and adult hypostome, thoracic segments, and pygidia. X 3. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56946, Princeton Univ.

Figure 6. *Welleraspis lata,* n. sp. Paratype free cheek. X 5. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56978, Princeton Univ.

Figure 7. *Welleraspis lata,* n. sp. Paratype free cheek. X 7. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56947, Princeton Univ.

Figure 8. *Welleraspis lata,* n. sp. Paratype young cranidium. X 9. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56955, Princeton Univ.

Figure 9. *Welleraspis lata,* n. sp. Paratype pygidium. X 4. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57029, Princeton Univ.

PLATE 3

FIGURE 1. *Welleraspis lata,* n. sp. Paratype cranidium and thorax. X 4. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56938, Princeton Univ.

FIGURE 2. *Welleraspis humilis,* n. sp. Holotype cranidium. X 7. *Bucksella brevis* beds, Limeport formation, 2½ miles northwest of New Hope, Pennsylvania. No. 56887A, Princeton Univ.

FIGURE 3. *Talbotina pennsylvanica,* n. sp. Holotype young cranidium. X 7. No. 56865a, Princeton Univ. Paratype adult free cheek, ventral view. X 7. No. 56865n, Princeton Univ. The small cranidium is that of a young example of *Bucksella limeportensis,* No. 56865c, Princeton Univ. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania.

FIGURE 4. *Talbotina pennsylvanica,* n. sp. Paratype cranidium and free cheek. X 3. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56865k, Princeton Univ.

FIGURE 5. *Talbotina pennsylvanica,* n. sp. Paratype cranidium and pygidia. X 4. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56878, Princeton Univ.

FIGURE 6. *Talbotina* aff. *degrasensis* Lochman Cranidium. X 5. Limeport formation, 2½ miles northwest of New Hope, Pennsylvania. No. 57056, Princeton Univ.

FIGURE 7. *Talbotina clarae,* n. sp. Holotype cranidium. X 8. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56977, Princeton Univ.

FIGURE 8. *Bucksella limeportensis,* n. sp. Holotype cranidium. X 6. *Talbotina pennsylvanica,* n. sp. Pygidium. X 6. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56867, Princeton Univ.

FIGURE 9. *Bucksella limeportensis,* n. sp. Paratype cranidium. X 4. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56865b, Princeton Univ.

FIGURE 10. *Bucksella limeportensis,* n. sp. Paratype cranidium. X 5. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56865d, Princeton Univ.

FIGURE 11. *Bucksella limeportensis,* n. sp. Paratype pygidium. X 4. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56865l, Princeton Univ.

PLATE 3

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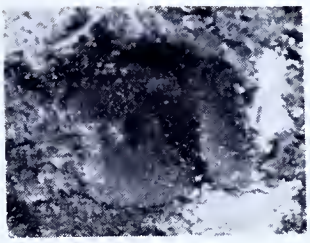

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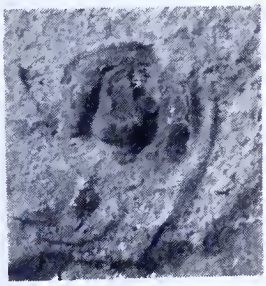

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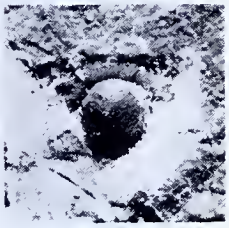

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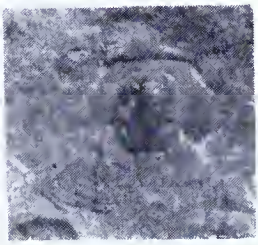

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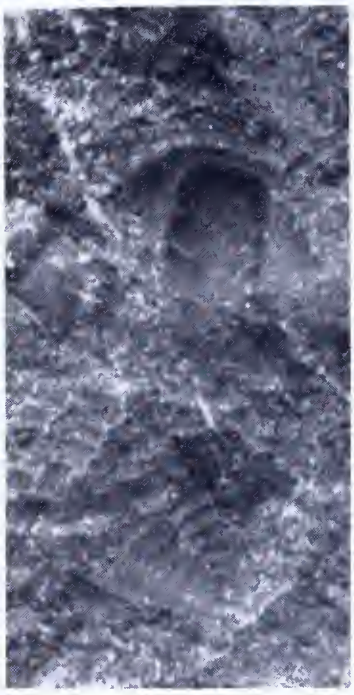

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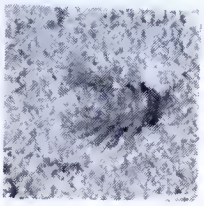

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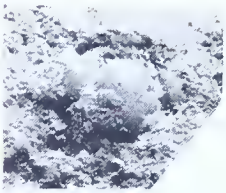
PLATE 4



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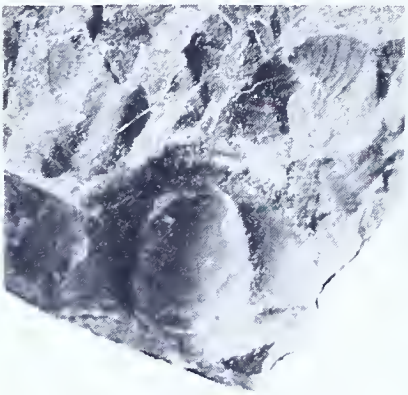

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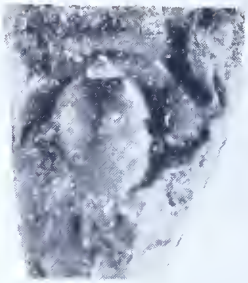

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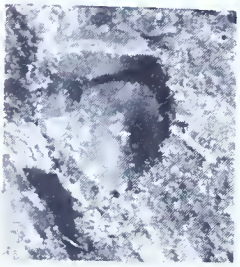

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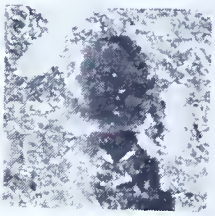

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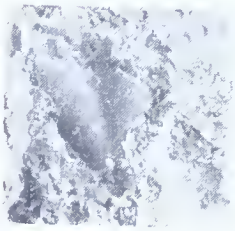

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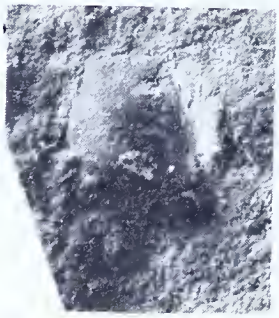

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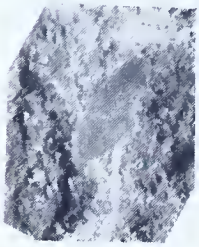

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Plate 4

Figure 1. *Bucksella brevis,* n. sp. Holotype cranidium. X 4. *Bucksella brevis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56886, Princeton Univ.

Figure 2. *Bucksella solitaria,* n. sp. Holotype cranidium. X 5. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57002a, Princeton Univ. The pygidium is that of a *Welleraspis lata,* No. 57002b.

Figure 3. *Bucksella solitaria,* n. sp. Paratype cranidium. X 7. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57004a, Princeton Univ.

Figure 4. *Bucksella solitaria,* n. sp. Paratype pygidium. X 7. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56961c, Princeton Univ.

Figure 5. *Bucksella longa, n. sp.* Holotype young cranidium. X 7. *Bucksella brevis* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56887b, Princeton Univ.

Figure 6. *Bucksella longa,* n. sp. Paratype free cheek. X 5. *Bucksella brevis* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56908, Princeton Univ.

Figure 7. *Lonchocephalus pennsylvanicus,* n. sp. X 6. *Talbotina pennsylvanica* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56891, Princeton Univ.

Figure 8. *Lonchocephalus parvulus,* n. sp. Holotype cranidium. X 4. *Bucksella brevis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56912, Princeton Univ.

Figure 9. *Lonchocephalus angustus,* n. sp. Holotype cranidium. X 6. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57017a, Princeton Univ.

Figure 10. *Coosia parva,* n. sp. Holotype pygidium. X 4. *Bucksella brevis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56888a, Princeton Univ.

Figure 11. *Coosia parva,* n. sp. Paratype free cheek. X 3. *Bucksella brevis* beds, Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56889, Princeton Univ.

PLATE 5

FIGURE 1. *Coosella lata,* n. sp. Holotype cranidium. X 5. *Welleraspis lata beds,* Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56994a, Princeton Univ.

FIGURE 2. *Genevievella pennsylvanica,* n. sp. Holotype cranidium. X 2. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 56971. The small shield is a cranidium of *Welleraspis lata,* n. sp.

FIGURE 3. Trilobite, genus and species undetermined. Pleuron. X 2. *Lingulepis pinnaformis beds,* Limeport formation, 2 miles northwest of New Hope, Pennsylvania. No. 56890, Princeton Univ.

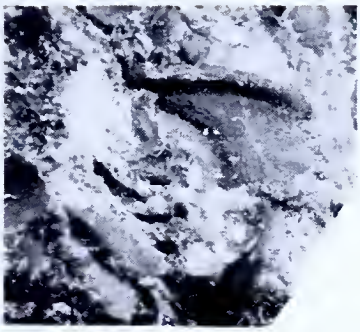
FIGURE 4. *Indianites minutus,* n. sp. Holotype left valve. X 10. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57014.

FIGURE 5. *Indianites perpusillus,* n. sp. Holotype right valve. X 20. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57026a, Princeton Univ.

FIGURE 6. *Indianites perpusillus,* n. sp. Holotype right valve. X 30. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57026a, Princeton Univ.

FIGURE 7. *Indianites limeportensis,* n. sp. Holotype right valve. X 10. *Welleraspis lata* beds, Limeport formation, Limeport, Bucks County, Pennsylvania. No. 57054, Princeton Univ.

PLATE 5



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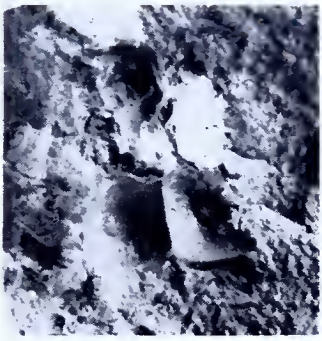

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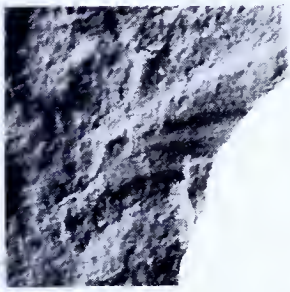

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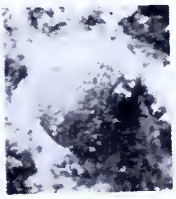

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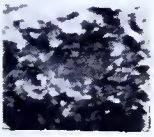

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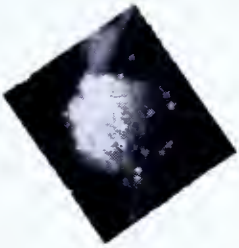

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